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HUMAN FACTORS STUDY OF DESIGN CONFIGURATIONS
FOR THE LASER RANGE FINDER

by

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and

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DA Project 513-07-010

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ABSTRACT

An experiment was conducted to compare the accuracies of the proposed design configurations for the LASER Range Finder (shoulder-operated vs. bipod-mounted vs. high tripod-mounted vs. low tripod-mounted). The tripod-mounted configurations provided greatest accuracies.

Following the experiment, the observers participated in non-structured oral critiques of the design configurations and completed a written questionnaire. The oral and written critiques attempted to elicit from the observers design preferences and design suggestions considering combat conditions. A majority of the observers preferred the low tripod-mounted configuration and stated that this configuration would be the most practical in combat. A summary of the critiques is presented.

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BACKGROUND

The Fire Control Division, Frankford Arsenal, began the design and construction of a breadboard LASER Range Finder in December 1961 and completed it in March 1962. At this time the breadboard was demonstrated for the Artillery Board at Fort Sill. The Artillery Board recommended an immediate investigation of configuration requirements in order to insure an optimal design of the final system. Legitimate questions were raised concerning a tripod-mounted system vs. a shoulder-held system vs. a bipod-mounted system. These questions were related to the advantages and disadvantages in terms of weight and speed, accuracy and reliability of operation. The Artillery Board, therefore, recommended that appropriate mock-ups be fabricated using cameras to record sightings. These mock-ups were then to be used to conduct a human factors engineering study to obtain definitive answers to the pertinent design questions.

The Fire Control Division, Frankford Arsenal, immediately began the design and construction of the mock-ups. Together with the Human Factors Engineering Branch, and with the assistance and cooperation of the Artillery Board, they then planned and carried out the experiment presented in this report.

To the best of our knowledge, this is the first time that human factors engineering has been brought into an R&D program so early in order to insure optimal design from the standpoint of the "User". The advantages of such early consideration have been propounded and extolled for a number of years. There should be no need for enumerating them here. There is no doubt that this effort will prove worthwhile in assuring an optimal system and in minimizing costly changes later in the program.

PURPOSE

As the reader has gathered from the above, the primary purpose of this experiment was to determine which of three

systems, tripod-mounted, shoulder-held or bipod-mounted, is best for the task of ranging with the LASER Range Finder by a forward observer. This determination was to be made by empirical study supported by opinions of experienced and inexperienced forward observers taking part in the experiment.

A secondary purpose was to obtain data concerning other design features that would improve the system and the overall operation of laying artillery fire and to uncover potential problem areas that may otherwise be overlooked.

DESCRIPTION OF EQUIPMENT AND FACILITIES

A. Breadboard LASER Range Finder

A picture of the breadboard LASER Range Finder is shown in figure 1. For the purpose of this report the description of the breadboard can be limited to a description of the operator's task. The operator using the elbow telescope rotates the traverse and elevation knobs until his target is properly positioned within his reticle. The operator now simply depresses a microswitch and the range is recorded on a digital readout.

B. Tripod Mock-up

The tripod mock-up is shown in figure 2. It is designed to essentially simulate the weight, configuration and operation of the proposed LASER Range Finder. The upper telescope is used by the operator to sight on target and has 6x magnification. The lower telescope attached to the camera has 20x magnification. The rectangular section beneath the eyepiece contains the camera and solenoid and batteries for automatically operating the camera. This automation includes film advance as well as film exposure. After sighting on target using the traverse and elevation knobs, the observer depresses the hand-held switch shown clipped to the side of the mock-up, thereby photographing his sight picture and advancing the film for the next frame.

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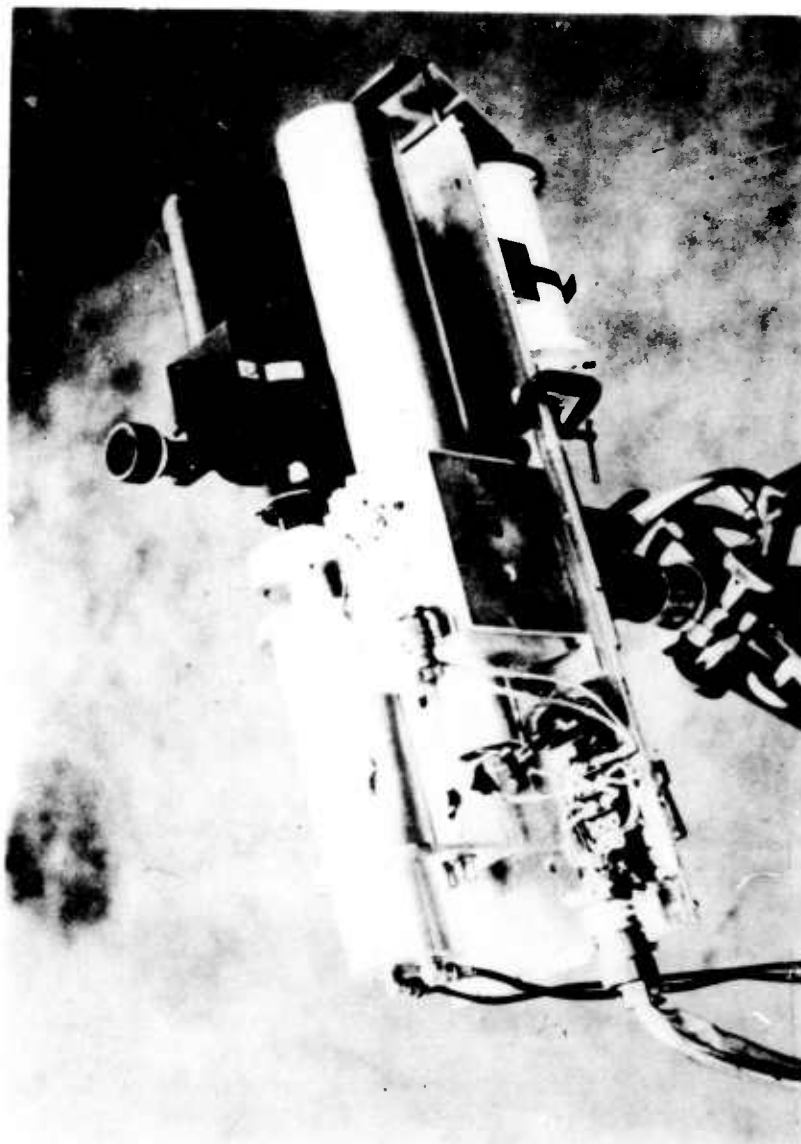


Figure 1. Breadboard LASER Range Finder

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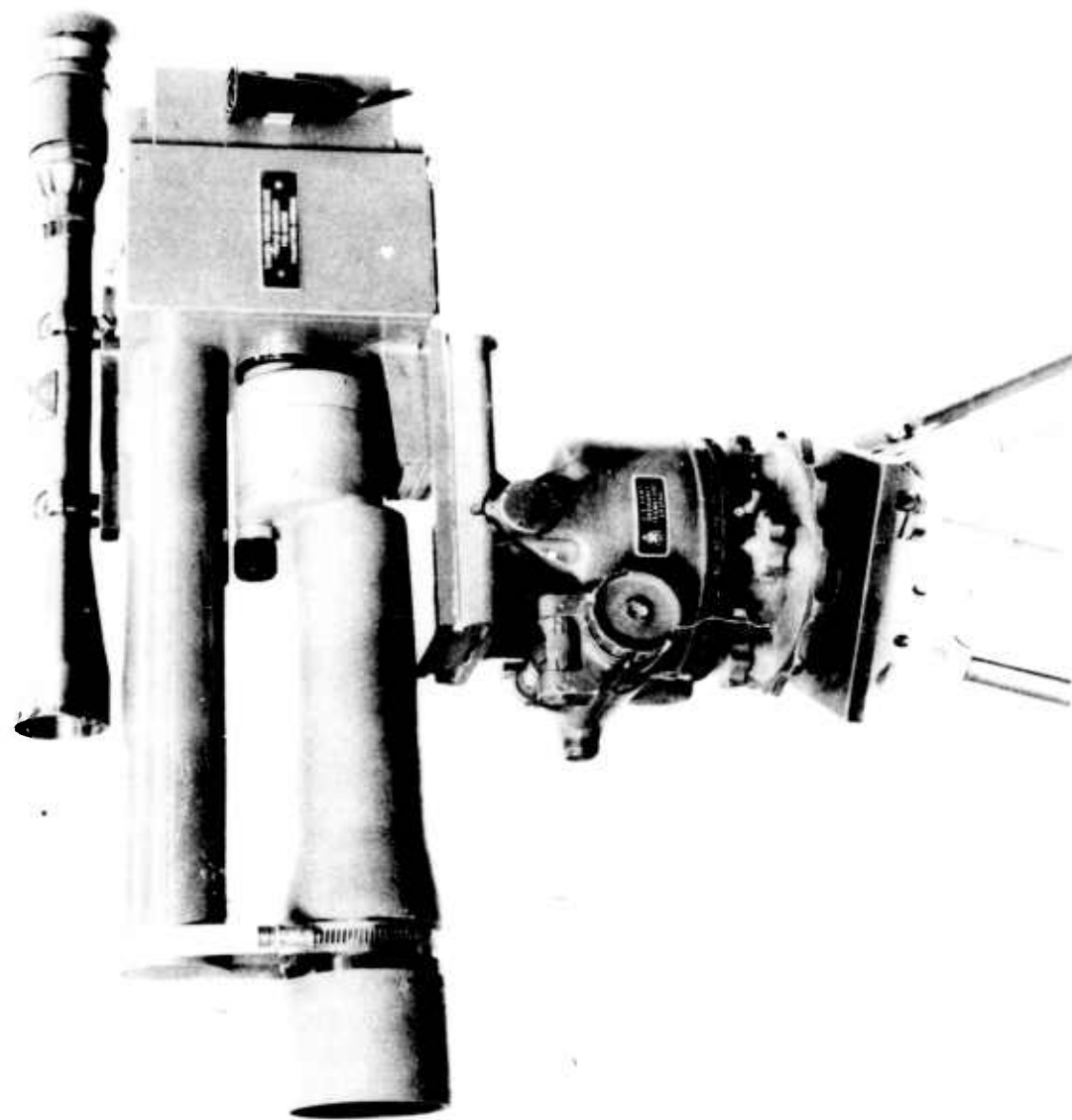


Figure 2. Tripod Mock-up

C. The Combination Bipod/Shoulder-Held Mock-up

This mock-up is shown in figure 3 with its bipod in position. This same instrument served as the shoulder-held system with the bipod folded away. All of the features of this mock-up are the same as those of the tripod mock-up except that the camera equipment is contained in the rifle stock and direct motion of the instrument is made without the use of traverse and elevation knobs.

D. West Range Targets

	<u>Azimuth (mils)</u>	<u>Range (meters)</u>
1. Bunker on ridge of hill.	5695.00	1786.90
2. Tree stump.	4761.70	305.14
3. Remains of a tank hull.	4303.90	2798.45
4. Small tree near bend of road.	3330.90	946.53
5. Small lone rock.	4689.50	2889.55

E. East Range Targets

1. Horizontal part of road halfway between tree and telephone pole.	195.4	1483.79
2. Top half of culvert on right side of road.	261.6	1647.03
3. Sandbag emplacement.	2562.8	1154.45
4. Small clump of bushes, 2 mils from nearest tree line.	2960.6	1762.25
5. Sign on telephone pole.	?	?

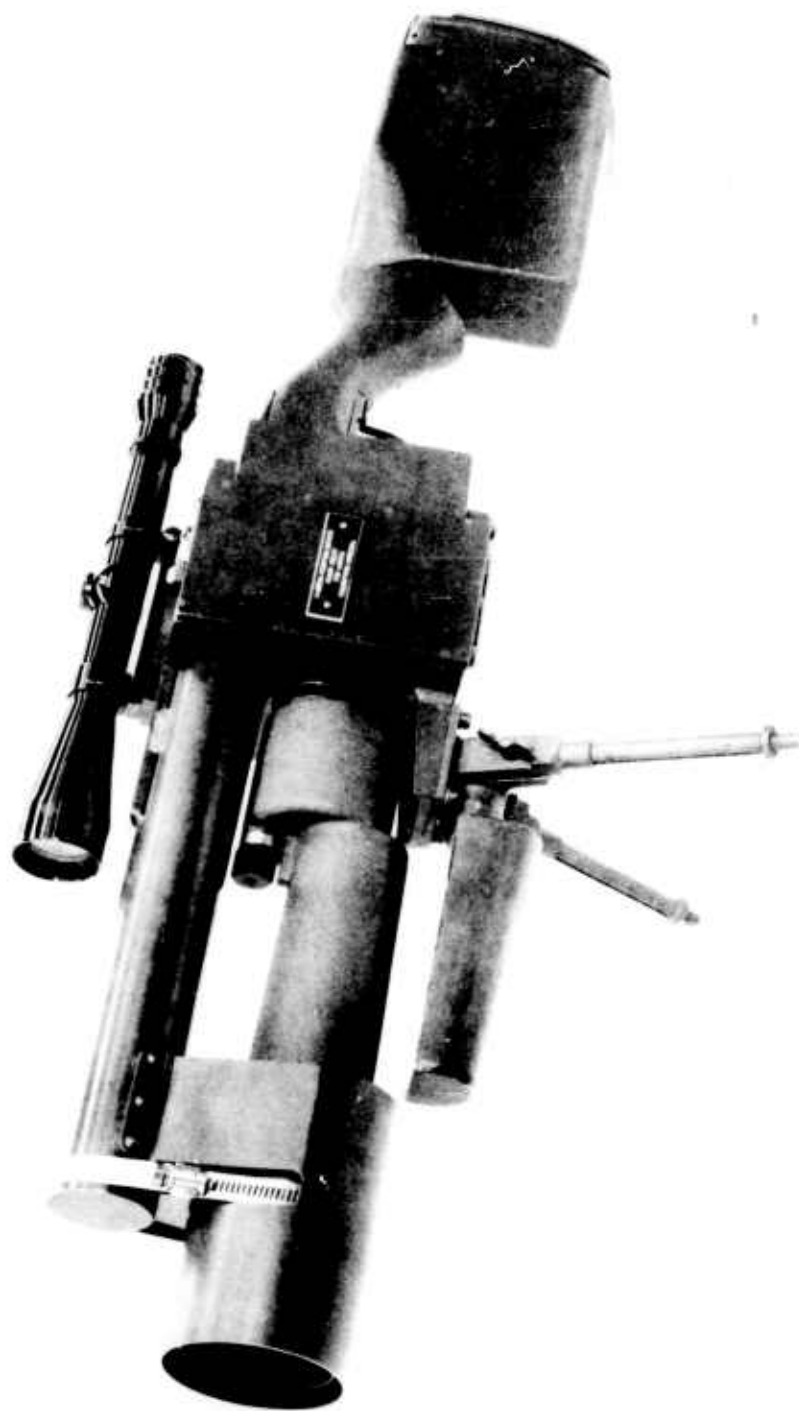


Figure 3. Combination Bipod/Shoulder-Held Mock-up

Prior to performing their tasks with the mock-ups, the observers were given instruction concerning the actual LASER Range Finder and were permitted to do some ranging using the LASER breadboard.

It was important that this training be given since correct aiming of the LASER Range Finder involves more than simply laying a cross-hair. It might be well at this point to describe and illustrate correct and incorrect lays.

The reader is referred to figure 4. This is a picture of the target and superimposed reticle just as the observer and camera would see them. Imagine that the four central corners of the reticle are connected by imaginary straight lines forming an enclosed square. This square represents the receiving area of the photo cathode tube. The returning light signal must enter a portion of this area in order to stop the counter (timer), thus giving the range to the object from which the light has been reflected. The first light signal returning to this area stops the counter. Therefore, if all of the light returning to this area comes from the target alone, the correct range is recorded. In other words, if the observer aims high so that part of the target is seen in the square and the remainder of the square consists of more distant objects and background, the first signal will come from the target and will give a correct range. An incorrect range is recorded when the observer places the foreground or objects nearer than the target inside the square, or when distant objects are included without a part of the target. Examples of these two errors are shown in figures 5 and 6, respectively. For the breadboard used in this training, there was a rejection circuit available to reject signals returning before a pre-set time. Thus, as long as the target could be seen, a correct range could be recorded by rejecting signals coming from foreground clutter. For example, let us assume that a target is located at approximately 2000 meters and that it is impossible to lay on the target without having a tree branch located at about 1200 meters projecting into the field of view. The rejection circuit can be set to reject signals returning from 1500 meters or less, thus eliminating the signal from the tree branch and yielding a correct range to target.

Since this experiment was conducted, Frankford Arsenal has developed a more refined rejection circuit that increases the

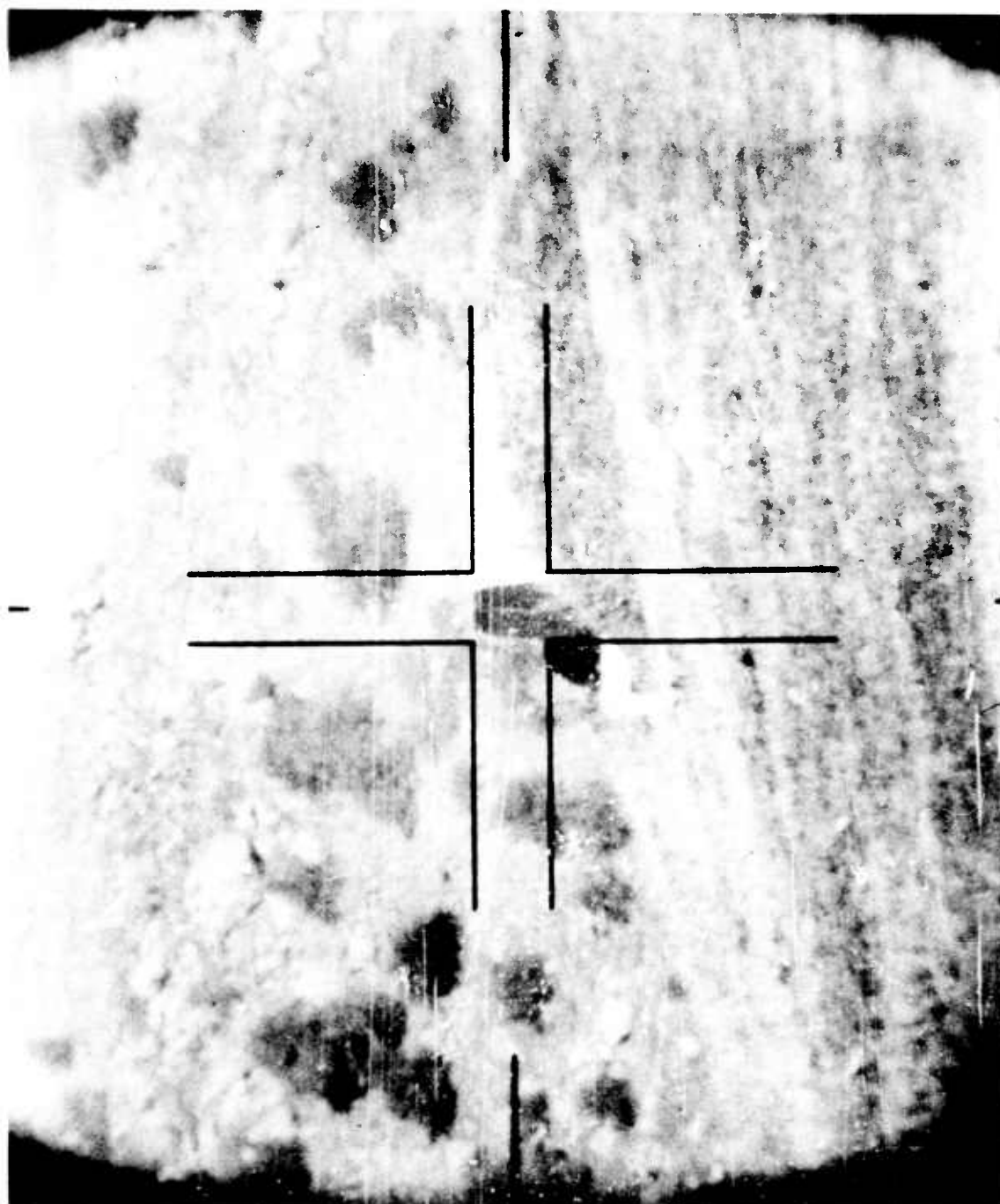


Figure 4. A correct lay for the LASER Range Finder and the camera mock-up.

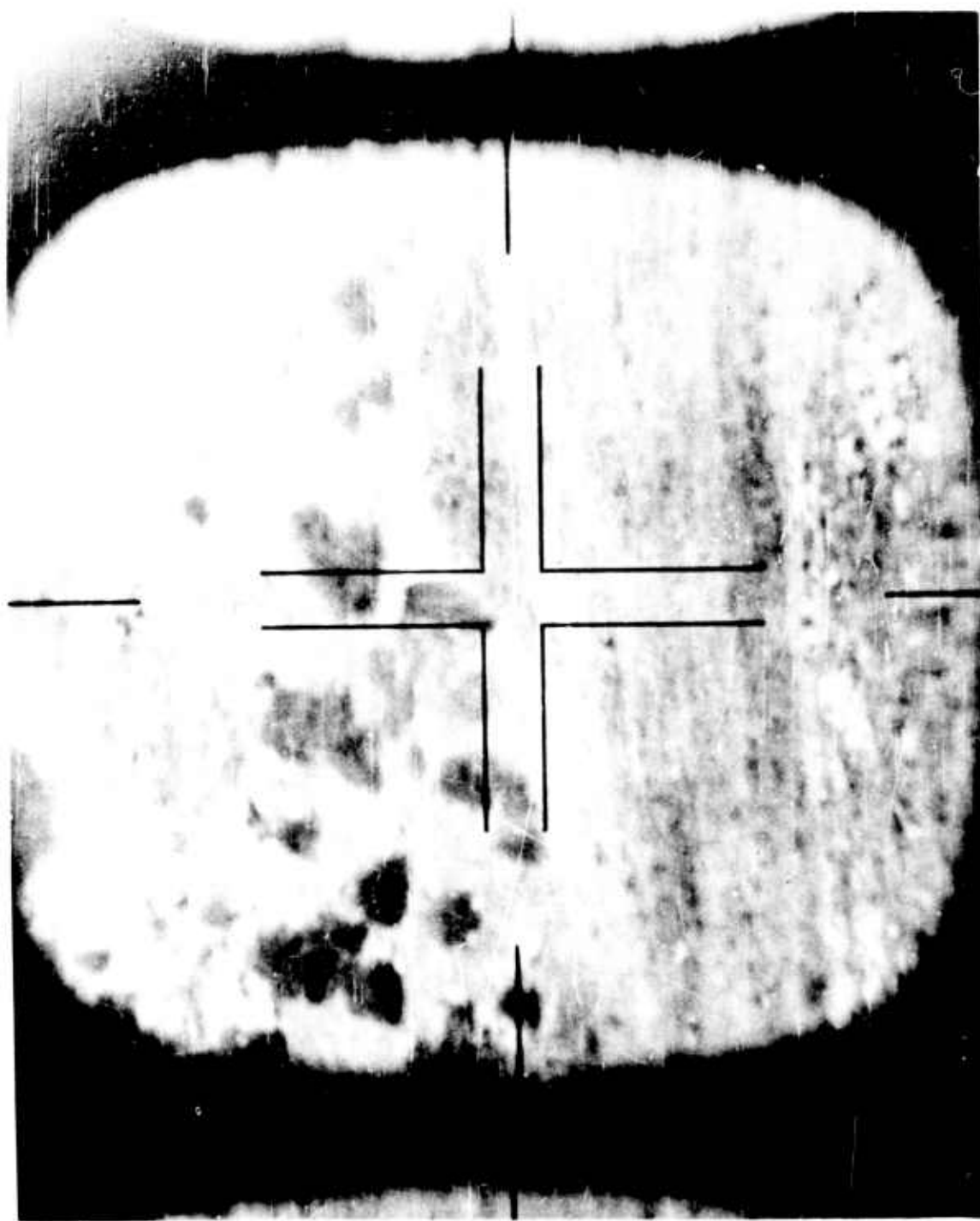


Figure 5. An incorrect lay: the readout will indicate range to foreground rather than bunker.

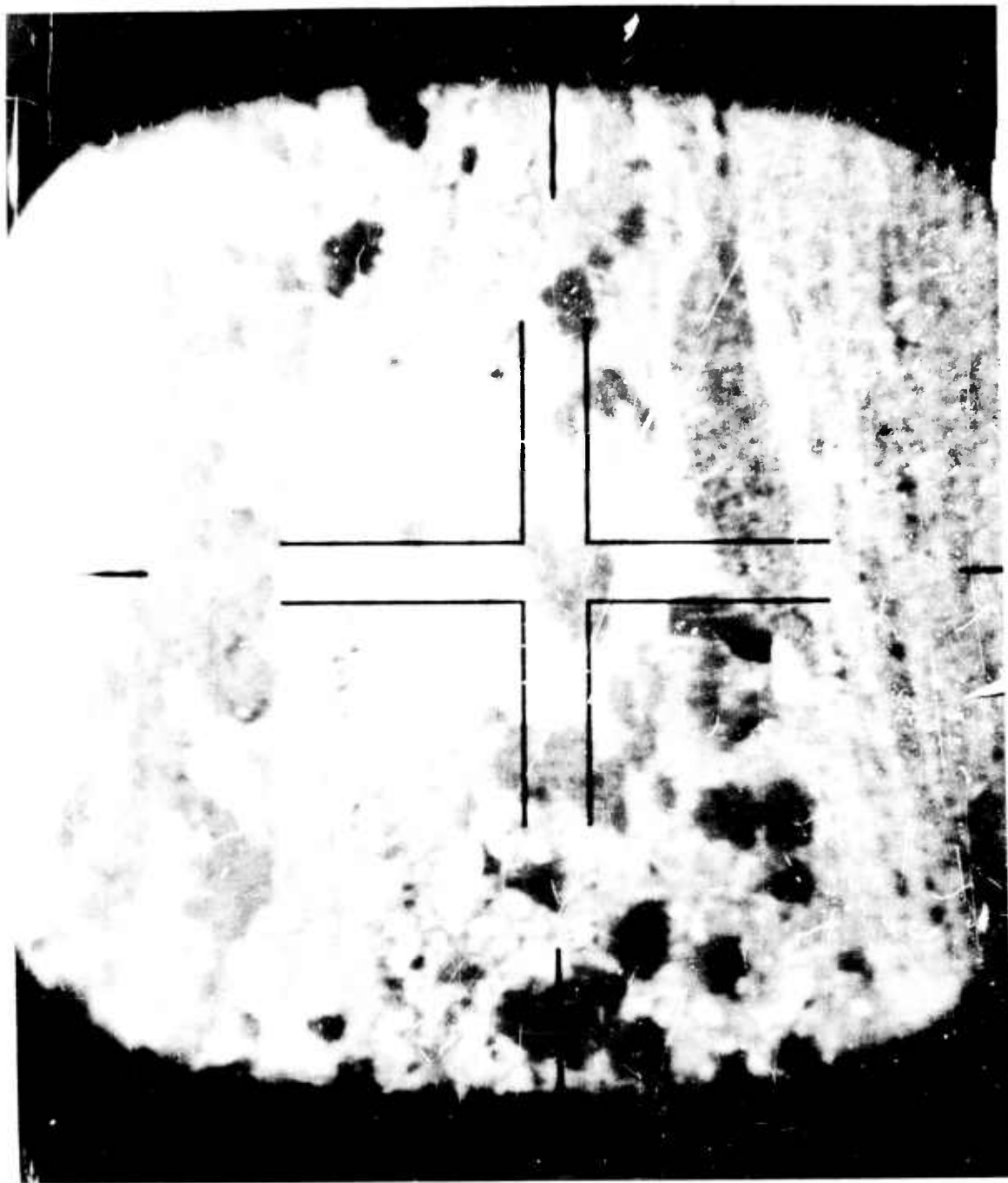


Figure 6. An incorrect lay: the readout will indicate range to background rather than bunker.

capabilities of the LASER Range Finder. With this circuit, the number of return signals is presented to the operator on a nixie tube. A separate switch numbered from one to five is used by the operator to select one of the signals to stop the counting circuit. In operation the operator would dial in the number shown by the display so that the target signal will stop the range counter.

The experiment was conducted in two phases. The first phase was intended as a preliminary experiment to determine whether or not the shoulder-held standing position and/or the shoulder-held prone position should be omitted as variables from the main experiment. The purpose here was to try to reduce the complexity and duration of the main experiment.

A total of 28 operators, hereafter referred to as "observers", were used in these experiments, 4 in Phase I and 24 in Phase II.

After the observers completed half of the experiment, a critique was conducted with groups of 4 observers at a time. During the first part of the critique, the observers were encouraged to talk freely concerning any aspects of the mock-ups, the experiment itself, the present and future plans for the design of the LASER Range Finder and the usefulness of the instrument in the field. These discussions were conducted by a psychologist using the non-directive technique as much as possible. The discussions were recorded on magnetic tape.

In the second part of the critique the observers were asked to complete a questionnaire designed to elicit more specific information.

PHASE I

Description of Experiment

The 4 observers in Phase I consisted of 3 Lieutenants and 1 Captain with basic knowledge of forward observer techniques gained from an orientation course at the ~~Infantry~~ ^{Artillery} School.

There were 5 combinations of camera mock-ups and observer positions which we shall hereafter refer to as positions. These positions were:

- A. Tripod-mounted system - high.
- B. Tripod-mounted system - low.
- C. Shoulder-operated system - prone.
- D. Bipod-mounted system - prone.
- E. Shoulder-mounted system - standing.

Each observer was given 3 trials for positions A, C, and D and 6 trials for positions B and E. However, observer 3 did not receive the 3 additional trials for position E. The reasons for the unequal number of trials involve the number of frames available for each roll of film, the number of changes of film, the number of changes of the experimental variables, and the desire to keep each observer's data grouped together.

Observers 1 and 3 began with the tripod-mounted systems, completed their trials with these systems and then moved to the bipod and shoulder-held systems located approximately 50 feet to the left. Observer 1 began with the high tripod and observer 3 began with the low tripod. Observers 2 and 4 worked in the reverse order, i.e. beginning with the bipod and shoulder-held systems. Thus the conditions were counterbalanced among the observers. This design is summarized in table I.

Table I. SUMMARY OF DESIGN OF PHASE I EXPERIMENT

<u>Observers</u>	<u>Trials</u>				
	<u>1-12</u>	<u>13-24</u>	<u>25-36</u>	<u>37-48</u>	<u>49-60</u>
1	A*	B	E	C	D
2	C	E	D	A	B
3	B	A	E	C	D
4	C	E	D	B	A

*The letters, A, B, C, D, & E represent the positions listed above. For example, "A" represents tripod-mounted system-high.

RESULTS

The results for the individual observers are shown in table II. The data are in terms of correct (C) and incorrect (I) laying (i. e. simulated ranging).

Because of the counterbalancing of conditions among the observers, it would not be scientifically correct to base conclusions concerning the original hypothesis on individual data. The individual data, however, are extremely important when they show that the relative performance of the positions is consistent from observer to observer. In view of this, the reader should note that all observers had 100% correct lays for both tripod positions and their lowest percent correct lays for the two shoulder-held positions. Also 3 of the observers had 100% correct lays for the bipod system and 1 observer had 92% correct lays for this position.

The unequal number of trials limits the statistical treatment to percent correct lays. The magnitude of the differences, in view of the purpose of the experiment, is so great as to make this terminal statistic sufficient in itself to draw definite conclusions. The differences obtained leave no doubt about the inferiority of the two shoulder-held positions. Thus, in accordance with our original hypothesis, both of these positions could be eliminated from Phase II. In order to have a balanced experiment, however, the shoulder-held prone position was retained.

Table III presents a summary of the data for the individual observers and the grouped data for the 5 positions.

Table II. CORRECT (C) AND INCORRECT (I) LAYS ON EACH TARGET FOR EACH POSITION

Position	Targets												Percent Correct
	1			2			3			4			
	C	I	X*	C	I	X	C	I	X	C	I	X	
	Observer 1												
A	3	0		3	0		3	0		3	0		100
B	6	0		6	0		4	0		4	0		100
C	3	0		3	0		1	2		1	2		67
D	3	0		3	0		2	0	1	3	0	1	100
E	0	3		1	2		0	3		1	2		17
Observer 2													
A	3	0		3	0		3	0		3	0		100
B	6	0		6	0		6	0		6	0		100
C	-	-	3	3	0		3	0	2	1	0	5	100
D	-	-	3	3	0		3	0		3	0	3	100
E	-	-	5	-	-	3	2	2		0	2	1	33
Observer 3													
A	3	0		3	0		3	0		3	0		100
B	7	0		7	0		7	0		6	0		100
C	1	2		3	0		1	2		2	0		64
D	3	0		3	0		3	0		3	0		100
E	0	3		1	2		0	3		0	3		8
Observer 4													
A	4	0		3	0		3	0		3	0		100
B	5	0		6	0		6	0		6	0		100
C	-	-		-	-		0	6		1	2		11
D	2	1		3	0		3	0		3	0		92
E	0	3		1	2		0	4		0	2	1	9
Totals													
	C	I	X	C	I	X	C	I	X	C	I	X	

*The letter "X" represents data lost through film failure.

Table III. SUMMARY OF CORRECT (C) AND INCORRECT (I) LAYS FOR 4 OBSERVERS

Position	Observers								Percent Correct	
	1		2		3		4			Total
	C	I	C	I	C	I	C	I		
A	12	- 0	12	- 0	12	- 0	13	- 0	49 - 0	100
B	20	- 0	24	- 0	27	- 0	23	- 0	94 - 0	100
C	8	- 4	7	- 0	7	- 4	1	- 8	23 - 16	59
D	11	- 0	9	- 0	12	- 0	11	- 1	43 - 1	98
E	2	- 10	2	- 9	1	- 11	1	- 11	6 - 41	13

PHASE II

This phase is the main experiment in which 24 observers took part. These 24 observers consisted of:

1. Eight officers with combat experience as forward observers.
2. Four non-commissioned officers with combat experience and familiarity with forward observer techniques.
3. Twelve 2nd Lieutenants with basic knowledge of forward observer techniques obtained from the orientation course at the Artillery School, Fort Sill.

Only 4 positions were used in this phase. These were:

- A. Tripod-mounted system - high.
- B. Tripod-mounted system - low.
- C. Shoulder-operated system - prone.
- D. Bipod-mounted system - prone.

In addition to using more observers for this phase, there were also more targets. There were 5 targets used at the West Range (FP 128) and 5 targets used at the East Range (Flagg OP). The observers had an equal number of trials for each of the 4 positions at each of the two ranges.

The procedure for this phase was essentially the same as that for Phase I. The observers were first given orientation and practice ranging with the breadboard of the LASER Range Finder. The observers, taken 4 at a time, were given all of their trials at the West Range. They then attended their critique and then were given all of their trials at the East Range.

At both the West and East Ranges, each group of 4 observers worked in the same fashion as the 4 observers in the

first phase had worked. In other words the same counterbalancing was used as shown in table IV. This design was followed for each group of 4 observers.

The results for the West Range are shown in table V and the results for the East Range are shown in table VI. In both of these tables the results for all 24 observers have been combined for each position and for each target.

It was stated above that the observers received an equal number of trials for each of the operating positions. Tables V and VI indicate that some of these data have been lost. The data from only 7 trials have been lost for the West Range. From the East Range, the data from 61 trials were lost because of film failure and all data for target number 1 were omitted because of confusion on the part of the observers as to which was the designated target.

The data from these tables indicate that the observers scored better than 95% correct lays for both tripod-mounted positions, 88% and 82% for the bipod-mounted prone position, and 56% and 47% for the shoulder-held prone position. Thus the tripod-mounted positions were clearly superior to the other two positions. Even more indicative is the fact that the relative standing of the 4 operating positions was the same for both the West and East Ranges. This consistency should also indicate the reliability of these findings.

There is another very interesting point that should be noted concerning the data for the two ranges. All of the East Range trials were run after the West Range trials were completed. Ordinarily an experiment of this nature should yield better results for the East Range due to practice or learning. An examination of the data does indeed show improvement for the two tripod positions but an actual decrement for the bipod-mounted and shoulder-held systems. Because of the counterbalancing used in this experiment, we must conclude that this decrement is the result of a difference in the two ranges. It is generally agreed that the targets at the East Range were more difficult than those at the West Range, primarily because the terrain was more level and the targets were at the same level as the observers. We must conclude, therefore, that not only are the tripod systems superior to the bipod and shoulder-held systems, but that as the difficulty of the targets increases, this superiority is more pronounced.

Table IV. SUMMARY OF DESIGN OF EXPERIMENT FOR PHASE II*

<u>Observer</u>	<u>West Range</u>				<u>East Range</u>			
	<u>1-5</u>	<u>6-10</u>	<u>11-14</u>	<u>16-20</u>	<u>21-25</u>	<u>26-30</u>	<u>31-35</u>	<u>36-40</u>
5	A**	B	D	C	D	C	B	A
6	D	C	A	B	A	B	C	D
7	B	A	C	D	C	D	A	B
8	C	D	B	A	B	A	D	C

*This design is repeated for each group of 4 observers.

**The letters A, B, C, & D represent the positions listed above. For example, "A" represents tripod-mounted system - high.

Table V. CORRECT (C) AND INCORRECT (I) LAYS ON EACH TARGET FOR EACH POSITION

		<u>West Range</u>																		
		<u>Targets</u>																		
<u>Position</u>		<u>1</u>			<u>2</u>			<u>3</u>			<u>4</u>			<u>5</u>			<u>Totals</u>			<u>Percent</u> <u>Correct</u>
		<u>C</u>	<u>I</u>	<u>X*</u>	<u>C</u>	<u>I</u>	<u>X</u>	<u>C</u>	<u>I</u>	<u>X</u>	<u>C</u>	<u>I</u>	<u>X</u>	<u>C</u>	<u>I</u>	<u>X</u>	<u>C</u>	<u>I</u>	<u>X</u>	
A		20	2	2	22	0	2	23	1	0	24	0	0	21	3	0	110	6	4	95
B		23	1	0	24	0	0	20	4	0	24	0	0	24	0	0	115	5	0	96
C		10	12	2	21	3	0	10	16	0	15	9	0	10	14	0	66	52	2	56
D		21	3	0	24	0	0	20	4	0	19	4	1	21	3	0	105	14	1	88
Percent																				
Correct		80			97			76			86			79			84			

*The letter "X" represents data lost through film failure.

Table VI. CORRECT (C) AND INCORRECT (I) LAYS ON EACH TARGET FOR EACH POSITION

		<u>East Range</u>																			
<u>Position</u>		<u>Targets</u>																			
		1			2			3			4			5			Totals			Percent Correct	
		C	I	X	C	I	X	C	I	X	C	I	X	C	I	X	C	I	X		
A					17	0	7	19	0	15	20	0	4	19	1	4	75	1	20	99	
B	Omitted				18	1	5	18	0	6	18	0	6	18	0	6	72	1	23	99	
C					3	17	4	11	8	5	20	2	2	5	17	2	39	44	13	47	
D					12	11	1	19	3	2	23	0	1	21	2	1	75	16	5	82	
Percent Correct					63			86			98			76			81				

*The letter "X" represents data lost through film failure.

In table VII the data for the West Range and East Range have been combined. These data merely support the statements made above concerning reliability. An important aspect of these data bearing on the field use of the equipment should not be overlooked. The results indicate that the two tripod systems are superior to the other two systems for a variety of targets that are typical of those used by forward observers.

Table VII. RESULTS OF WEST AND EAST RANGES COMBINED

<u>Position</u>	<u>C</u>	<u>I</u>	<u>X</u>	<u>Percent Correct Lays</u>
A	185	7	24	96
B	187	6	23	97
C	105	96	15	52
D	180	30	6	86

OBSERVERS CRITIQUES

Following the formal experiment, the observers participated in an oral critique of the LASER Range Finder considering combat conditions, the design configurations studied in the experiment, and the conduct of the experiment. The twenty-eight subjects were interviewed in groups of four. The interviews were nonstructured; that is, the interviewer did not suggest the topics for discussion or attempt to limit or direct the discussions of the observers. The observers were allowed to discuss aspects of the LASER and the design configurations which were most pertinent to them. The interview groups were purposely kept small so that all the observers would participate in the oral critique and to allow a greater variety of views. These oral critiques were taped.

Following the oral critique the observers were given a written questionnaire. Twenty-seven of the twenty-eight observers

submitted written critiques. The first question asked the observers to review the desirable and undesirable characteristics of the shoulder-held, tripod-mounted, and bipod-mounted configurations. The second question asked the observers to rate the five positions studied in the experiment (shoulder-held standing/kneeling, tripod-mounted low, shoulder-held prone, tripod-mounted high, bipod-mounted prone). The four observers from the first phase rated the shoulder-held standing position. All other observers were asked to treat this position as a shoulder-held kneeling position and rate it even though they did not actually use this position.

The remaining questions asked the observer to make design suggestions and to evaluate the design configurations taking into consideration the job of the forward observer in combat. The observers were also asked to evaluate the reticle pattern and evaluate the conduct of the experiment.

The items on the written questionnaire were general in nature. The questions were formulated so that the observers could emphasize good points, bad points, and problem areas which were important to them without having their thinking channelized. The written questionnaire used in this experiment is presented in appendix A. The written critiques are presented in appendix B.

The following is a summary and analysis of the oral and written critiques of the observers concerning the LASER and the design configurations.

In general, the observers expressed enthusiasm about using LASER for range finding. Several observers stated that there has always been a need for an accurate range finding device for artillery and the LASER Range Finder seems to satisfy that need. The LASER could be used for initial ranging, fire adjustment, and target area survey. It would certainly increase first round hit probability for direct and indirect fire weapons and therefore increase surprise fire capabilities. However, the observers cited potential problem areas: weight, mobility, and maintenance.

The forward observer is presently burdened with considerable equipment which he needs to do his job effectively. The observers stated that the LASER system must offer the forward observers

other capabilities beyond the ranging capability. The range finder should be designed to incorporate some of the functions of the present equipment of the observer, for example, azimuth and vertical angle indicators. Although range determination is a difficult yet highly important job of the forward observer, the observers were willing to retain the present equipment rather than be burdened with a heavy device that gives them accurate range only.

Several observers stated that the weight of the system makes it undesirable for use by a forward observer who must travel on foot. These observers believe that the system could be used in permanent or semi-permanent observation posts, in tanks or armored personnel carriers, or in any situation where the system could be vehicle transported, e. g. surveys.

With regard to maintenance, the observers believed that the complexity of the system would warrant regular high echelon maintenance. The problem of boresighting the LASER beam and the sight was mentioned most often. Maintenance of the power pack was also mentioned. It should be noted that the observers foresaw these maintenance problems having only been exposed to a rough prototype of the LASER Range Finder. Further developmental work and advances in the state-of-the-art will simplify or eliminate these maintenance problems.

In rating the five positions used in the experiment (Question #2 on the written questionnaire) the observers generally gave the tripod-mounted positions high ratings. Nineteen of the twenty-seven observers rated the tripod-mounted low position as "very good"; the other eight observers rated this position as "good". The ratings of the positions by the observers are shown in table VIII.

An average rank for the positions was determined. The positions ranked as follows: tripod-low, bipod-mounted prone, tripod-mounted high, shoulder-held prone, shoulder-held kneeling/standing.

Twenty-two of the observers stated that the tripod-mounted configuration was the best configuration for the LASER Range Finder. The stability of the system and the capability of rechecking the sight picture were cited as the chief advantages of the

Table VIII. OBSERVERS' RATINGS OF POSITIONS

(Number of Observers = 27)

<u>Position</u>	<u>Very Good</u>	<u>Good</u>	<u>Fair</u>	<u>Poor- Very Poor</u>
Tripod-mounted system - high	16	7	3	1
Tripod-mounted system - low	19	8	0	0
Shoulder-operated system - prone	1	6	11	9
Shoulder-operated system kneeling/standing	0	2	8	17
Bipod-mounted - prone	14	10	3	0

tripod system. The mount of the tripod-mounted system could easily be equipped with vertical angle and azimuth indicators. The observers suggested that azimuth and vertical angle determining equipment be designed to allow rapid gross adjustment as well as fine adjustment. Such a capability is designed into the Aiming Circle M1. Locks and leveling bubbles should be included on the azimuth and elevation equipment.

The chief disadvantages of the tripod system are: weight, bulk, movement, and emplacement problems in fast moving situations.

Some observers suggested that the bipod configuration be retained but designed so that a tripod could be affixed. The range finder could be used with a bipod in fast moving situations (assaults), the forward observer carrying the tripod for use in more permanent situations. However, this would increase the total weight of the system.

The observers cited ease of concealment and increased stability as advantages for the tripod-mounted low configuration. The high-tripod configuration presents a high silhouette which is impractical in many combat situations. The high tripod was slightly unsteady in a moderate wind. Some of the observers complained that the low tripod was uncomfortable, being too high for an observer in the prone position. However, if the system on a low tripod were placed on the edge of a foxhole, it could be used comfortably by the observer. Several observers suggested adjustable legs for the tripod.

The bipod system ranked second to the tripod-mounted low system. However, comments by the observers indicate that the high rankings given the bipod system were made with reservations. The observers were impressed with the lightness (17 lbs.) and ease of mobility and emplacement of the bipod system. The bipod system also offers ease of concealment. The observers set high value on these characteristics of the bipod system, stating the accuracy of this system, although it was not as good as the tripod system, was "good enough." Several observers preferred both a bipod and tripod capability.

Main disadvantages of the bipod system cited are: unsteadiness, inability to recheck the sight picture after ranging, and relative inaccuracy for difficult targets.

Design suggestions for the bipod system included: a compass for azimuth determinations, adjustable bipod legs to compensate for uneven ground, swivel on bipod for azimuth and elevation changes.

Eighteen observers cited instability as a chief disadvantage of the shoulder-held configuration. However, several cited lightness of weight and mobility as chief advantages. Many believed that if the system were balanced, greater accuracy would be attained. One observer suggested that the power pack be separated from the system thus lightening the system considerably and making it less awkward to handle. Most observers found it very difficult to sight on small targets with the shoulder-operated configuration.

The reticle pattern was the subject of one of the questions in the written questionnaire. Twenty-three of the twenty-seven subjects

answered simply "No" to the question: Do you consider the reticle difficult to use? Two who found the reticle difficult to use believed practice would improve their performance.

The observers found the reticle easier to use against square or rectangular targets and smaller targets because the reticle lines did not obscure such targets. Two observers stated that the reticle was difficult to use on low or vaguely defined targets. Nine observers stated that there was no difference in the effectiveness of the reticle against different types of targets.

Thirteen observers answered "No" to the question: Would you prefer a different reticle pattern? Nine others suggested a reticle with an enclosed square. Two recommended minor changes in the present reticle.

With reference to the power of the sight, most observers preferred a low power sight with a wide field of vision. However, because the nature of the system requires extreme accuracy and necessitates that the observer be able to see small objects in front of the target, several observers suggested the use of an open sight for initial target acquisition and a high powered sight for final adjustment. One observer suggested a binocular sight - a low powered sight for quick target acquisition, a high powered sight for final adjustment.

CONCLUSIONS AND RECOMMENDATIONS

From the results obtained both from the objective and subjective parts of this study, there is one definite conclusion that can be made relating to the original purpose of the experiment. The tripod-mounted system is superior to the shoulder-held and the bipod-mounted systems. The Human Factors Engineering Branch of Frankford Arsenal has no reservations concerning this conclusion and therefore recommends the tripod-mount for the final LASER Range Finder with a high - low adjustment.

There are other recommendations to be made based on the findings presented in this report and based on the tape recordings that have been reviewed. They are:

1. Provision should be made for measuring azimuth and vertical angle.
2. Consideration should be given to providing a reticle consisting of a completely enclosed square.
3. Though the aim in developing a piece of equipment usually includes lightness of weight, simplicity of operation and maintenance, safety, ruggedness, portability and the like, it is important that the greatest possible attention be given to these factors for this particular instrument.
4. The instrument should incorporate functions of the BC Scope so that the scope may be eliminated as a piece of F.O. equipment. (See item No. 1 above.)
5. A thorough human factors study should be made of complete artillery operations incorporating the LASER, FADAC, and any other modern equipment showing promise. The purpose of this study would be to determine the needs of artillery for carrying out its missions in the quickest and most accurate manner. For example, it should be possible for an F. O. to enter a new area, obtain range and compass readings to one or two points and a target, feed this information back to FADAC and receive fairly accurate fire on the first round. Various combinations of equipment and procedures can be tested for various kinds of missions to arrive at optimal equipment and procedures. Admittedly this program would be quite extensive but the potential profit is worth the effort.

APPENDIX A

FORMAT OF THE WRITTEN QUESTIONNAIRE PRESENTED TO OBSERVERS

The purpose of the written part of this critique is to obtain your views in particular areas concerning the design of these two systems. Please feel free to make any comments you believe are important and may aid those developing the system. Answer as many questions as you can.

1. What design and operating characteristics of each of the following do you feel are desirable or undesirable?

- a. Shoulder-held
- b. Tripod-mounted
- c. Bipod-mounted

2. Rate each of the following positions on a scale from 10 to 1 in terms of your preference. The same rating may be given to more than one position. Use the following criteria.

10 - 8 Very good
7 - 5 Good
4 - 2 Fair
1 - 0 Poor and very poor

- a. Shoulder-held kneeling _____
- b. Tripod-mounted low _____
- c. Shoulder-held prone _____
- d. Tripod-mounted high _____
- e. Bipod-mounted prone _____

3. Were any of the 5 positions easier or more difficult with any particular types of targets? Cite examples.

4. What is your opinion of the reticle pattern?

- a. Do you consider it difficult to use?

- b. Was it more effective for certain types of targets? Cite example.
 - c. Would you prefer a different pattern and Why? Cite example.
5. Are there any battlefield conditions and environments under which you think either of the 5 positions would be ineffective or difficult to use? Explain where necessary?
 6. Are there any special problems you can visualize that may come up in the battlefield concerning carrying or operating this equipment?
 7. What suggestion do you have concerning the future design of the system.
 8. Comment on the manner in which the experiment was conducted? Cite factors which may have had a detrimental effect on your performance.
 9. Write any additional comments you wish concerning the equipment or the experiment.

APPENDIX B

OBSERVERS' RESPONSES ON WRITTEN QUESTIONNAIRE

Question 1. What design and operating characteristics of each of the following do you feel are desirable or undesirable.

a. Shoulder-held.

- Observer No. 1. The shoulder-held model is heavy enough to cause difficulty in accurate aiming at any great distance. A model that could be suspended from the neck as a camera would be more desirable.
- Observer No. 2. The inherent instability of this design defeats the purpose of the instrument. The position of the forward hand grip and the lack of the sling to steady the instrument are also important deficiencies.
- Observer No. 3. Undesirable -- too unstable, poor sight picture.
- Observer No. 4. This is undesirable due to the inability to obtain a desirable sight picture and ability to hold proper sight picture.
- Observer No. 5. I feel that if the weight were concentrated towards the shoulder and a telescopic bipod installed, ease of operation would be greatly enhanced.
- Observer No. 6. Very inaccurate and unstable -- I would prefer not using it as a Shoulder-held piece of equipment.
- Observer No. 7. Fair.
- Observer No. 8. Undesirable.

- Observer No. 9. (Impractical) and unstable, since I don't see how the F. O. could get an accurate recheck reading.
- Observer No. 10. None.
- Observer No. 11. I think shoulder-held is undesirable because during the time of combat you are only standing about 15% of the time and the other 85% you are on the ground.
- Observer No. 12. To be usable, the device should be well-balanced and should not weigh more than about ten pounds. Any additional weight should be attached by cables.
- Observer No. 13. Very difficult to sight on target. Based on the necessity of actually sighting on the target, false readings would be frequent.
- Observer No. 14. The sighting requirements being what they are I don't think the system can be counted on in this position. This isn't much of a problem since using it this way would be necessary only in an emergency.
- Observer No. 15. Due to weight and CG, instrument cannot be sufficiently stabilized to obtain satisfactory pointing on small targets.
- Observer No. 16. This design is very unsteady due to the weight and bulkiness of the equipment and the human error which enters. I feel that this design is defeating the purpose of the LASER because of the false ranges which would be received in some cases.
- Observer No. 17. Not desirable -- due to operator's inability to hold steady.
- Observer No. 18. Favorable -- light weight, mobility.
Unfavorable -- poor balance, difficult to keep on target.

- Observer No. 19. 1. Too heavy to be used hand-held.
2. Weight is poorly distributed.
3. Lightest of the three designs.
- Observer No. 20. This capability should be incorporated into the design characteristics, however, it should be considered the least desirable of the means of operation.
- Observer No. 21. Seems impractical due to weight and balance of the equipment.
- Observer No. 22. Too heavy and bulky. Would be alright for quick emplacement.
- Observer No. 23. Is undesirable in this position. If the LASER is designed to be used in this position, it should be better balanced.
- Observer No. 24. Undesirable because of the inaccuracies involved. The weight of the machine would be too heavy for the average person to hold accurately on a target.
- Observer No. 25. The weight of the instrument tends to affect the stability of sighting after two or three shots.
- Observer No. 26. The support above the stock was helpful. The stock should be longer for a more natural feeling. I missed the "spot weld" of my thumb and cheek. If the stock was made to allow this "spot weld" the feeling of the instrument would be natural. It would be desirable to be able to brace the elbow or rear of the upper arm against the body when standing for added support. Maybe an extension below the barrel would be an answer.
- Observer No. 27. In this position, accuracy may be reduced due to the weight of the machine. Many people find it hard to hold a device such as this in such a position for a long period of time. The most inaccurate of all the positions as far as results are concerned, but probably the fastest.

Question 1. What design and operating characteristics of each of the following do you feel are desirable or undesirable.

b. Tripod-mounted.

Observer No. 1. Is a good design for use in a semi-permanent or permanent situation. It would be desirable to have a reticle similar to binoculars.

Observer No. 2. Of the three configurations used, this was the easiest to use and produced the best results. The low, or ground-mounted tripod was by far and away the best of the three configurations used and should be the one worked on. The major deficiency is bulk, which could be overcome with further development.

Observer No. 3. Most desirable -- Should be mounted on a light low (12" high) base with an azimuth and a vertical angle counter. There should be a fast and a slow motion and a lock on the target when the proper sight picture is obtained. There should also be an adjustable high-tripod base provided.

Observer No. 4. Very good in that it is a steady device that enables the observer to obtain and hold a good sight picture. It is undesirable due to exposing observer.

Observer No. 5. No answer.

Observer No. 6. Good if we desire it to replace the B. C. Scope. Design a tripod to determine azimuth to target.

Observer No. 7. Good.

Observer No. 8. Desirable.

Observer No. 9. Is the most accurate method since it is more stable and a definite reading can be obtained and an accurate recheck made if it was necessary.

- Observer No. 10. A light-weight ball and socket mounted, adjustable legs with a 20 traverse and elevation device built into the range finder.
- Observer No. 11. Tripod-mounted is a very good method for long range O. P. or where mobility is good.
- Observer No. 12. Magnetic needle should be included for reference to magnetic north. Because of the circuitry and magnetic interference, it may be necessary to be able to use this needle before mounting the LASER equipment.
- Observer No. 13. Good.
- Observer No. 14. No answer.
- Observer No. 15. No answer.
- Observer No. 16. The tripod is by far the most steady position and I feel that the best performance would be obtained using this design. I believe the low tripod mount with a means of measuring vertical and horizontal angles would be ideal. A pistol grip with squeeze-type trigger would also help.
- Observer No. 17. Best for semi-permanent instrument. Will be bulky to carry on foot.
- Observer No. 18. Favorable --steadiness on target, high accuracy. Unfavorable -- time loss in setting up and taking down.
- Observer No. 19. For a fixed O. P. the tripod is best for more comfortable operation.
- Observer No. 20. This is the most desirable. A mount similar to the old "light Machine Gun" mount with ability to traverse and elevate should be used. Traverse should approximate 180° , elevation in the neighborhood of 15° and depression perhaps 30° .

Observer No. 21. Desirable: Most accurate means of support.
Undesirable: Added weight, cumbersome - especially for high tripod.

Observer No. 22. Very stable and accurate.

Observer No. 23. I consider this characteristic to be the most desirable, but the system should be capable of being bipod-mounted too.

Observer No. 24. Desirable. If it could be mounted on a ground type mount such as the B. C. scope mount. Will give accuracy desired and can obtain azimuth and vertical angle readings.

Observer No. 25. A very stable system but does not afford the portability of the bipod which was also stable.

Observer No. 26. Very stable.

Observer No. 27. Excellent position; accurate and will yield the truest ranges. Very stable and from this position you can get an excellent sight picture. It may be slow in swinging to a target due to the azimuth scale.

Question 1. What design and operating characteristics of each of the following do you feel are desirable or undesirable?

c. Bipod-mounted.

Observer No. 1. No answer.

Observer No. 2. This would be a satisfactory configuration but would limit development of a better system if this were followed. One of the drawbacks is the lack of easy maneuverability which would allow the instrument to be used with facility and rapidity.

- Observer No. 3. Satisfactory -- I do not believe it provides the capabilities available with the tripod-mounted LASER.
- Observer No. 4. Bipod-mounted is a good device, but limits the observer in that the bipod should have legs that can be elongated or shortened as the situation requires.
- Observer No. 5. No answer.
- Observer No. 6. Very suitable. I would design a compass into the equipment so as to get relatively rough azimuth and accurate range.
- Observer No. 7. Very good.
- Observer No. 8. Undesirable.
- Observer No. 9. Could be made very suitable if a rear leg was used on the piece for more stability.
- Observer No. 10. Good, but desire adjustable legs.
- Observer No. 11. This method is best of all because it is easy to move around, also can be used with or without, same as the old B.A.R. bipod mount.
- Observer No. 12. If possible a compass should be included for measuring azimuth.
- Observer No. 13. Best for combat operations.
- Observer No. 14. Although the tripod system is a little more stable, I feel the bipod system is the best one. It meets the stability requirements demanded by the sight and still enables a low profile. Thinking of combat, the bipod system seems superior to the others. One possibility would be a small base tripod which would fold and also an azimuth indicator, I think the gun-type design is the best system.

- Observer No. 15. Bipod should have a swivel.
- Observer No. 16. The bipod is much more accurate than the shoulder mount, but still it is shaky, especially in a wind, which would lead to false ranges.
- Observer No. 17. Bipod would be better with a swivel to allow traverse by movement of operator's body.
- Observer No. 18. Favorable - light weight, mobility, accuracy. Unfavorable - high possibility of ranging on high grass in foreground between ranger and target, particularly when the target is appreciably below the ranger.
- Observer No. 19. Ease of carrying on foot by F. O., better than the tripod-mounted. More easily handled in prone position.
- Observer No. 20. Second choice for design and operation. Fold away bipod with adjustable height of legs.
- Observer No. 21. Seems adequate for most hasty operations. Configuration, as at present, with bipod built in plus the tripod capability seems OK.
- Observer No. 22. Very good for quick emplacement and is fairly stable.
- Observer No. 23. Probably the most desirable in combat conditions.
- Observer No. 24. This would cause inaccuracies if used for a long period of time because of the uncomfortable position and condition of the user.
- Observer No. 25. No answer.
- Observer No. 26. Very stable. However, the bipod legs could be adjustable in length to compensate for cant when using the instrument on a slope.

Observer No. 27. An acceptable method - fast and has a higher degree of accuracy than the shoulder-held position. This would be my second choice after the tripod-mounted.

Question 3. Were any of the 5 positions easier or more difficult with any particular types of targets? Cite examples.

Observer No. 1. Small targets partially obscured by other objects when using as a shoulder-held device.

Observer No. 2. The easiest of these positions is the low tripod and this would be the most practical configuration in my opinion.

Observer No. 3. No answer.

Observer No. 4. With shoulder-held prone, small targets were hard to center for correct sight picture.

Observer No. 5. Prone with bipod is easier to engage targets over 1 mil in width. Tripod (high or low) easiest to engage targets under 1 mil in width.

Observer No. 6. No answer.

Observer No. 7. The shoulder-held method is a little difficult in a strong wind.

Observer No. 8. No answer.

Observer No. 9. Tripod-mounted high produces more accuracy.

Observer No. 10. No answer.

Observer No. 11. The prone free-hand position. I think that was due to the weight of the equipment.

Observer No. 12. Tripod-mounted is easier with small targets. Targets closely obscured by brush are easier in prone position where device can be tilted.

- Observer No. 13. All point targets were difficult to get precision sighting using shoulder-held method due to lack of stability and wind velocity.
- Observer No. 14. Shoulder-held was unsatisfactory on almost all targets. Bipod and tripod were easy on all targets.
- Observer No. 15. No answer.
- Observer No. 16. I feel that the low tripod was by far the best on all targets encountered thus far, due to the steady support given.
- Observer No. 17. Tripod is easiest. The sight picture can be made and the instrument left laid. Other positions depend on operator for at least one point of support.
- Observer No. 18. Tripod and bipod mounts are easier to hold sight picture on long range targets. Low tripod and bipod positions are difficult to clear grass on close-in targets, particularly one much lower than O. P.
- Observer No. 19. The fork in the road was difficult for positioning the reticle pattern.
- Observer No. 20. Prone, bipod mount was difficult with targets of elevation (higher than operator). Mount must be adjustable.
- Observer No. 21. No answer.
- Observer No. 22. No answer.
- Observer No. 23. No answer.
- Observer No. 24. It was easier to sight on trees rather than bunkers and tanks using the shoulder-held standing and shoulder-held prone positions.
- Observer No. 25. Shoulder-held standing position was more difficult for all targets.

Observer No. 26. No answer.

Observer No. 27. The shoulder-held positions were much harder for all types of targets, especially the bunker. The other positions were much easier.

Question 4. What is your opinion of the reticle pattern?

- a. Do you consider it difficult to use?
- b. Was it more effective for certain types of targets? Cite example.
- c. Would you prefer a different pattern and why? Cite example.

Observer No. 1. a. No. For expanded use, I believe it should have a graduated reticle pattern.

Observer No. 2. a. No.

- b. It was easier to use for small targets then transfer to large target.
- c. I believe it would help to alter the reticle to include the square of the open cross.

Observer No. 3. a. I do not consider it easy to use, however, it is not difficult.

b.

- c. I would prefer a box type reticle pattern which incloses the target.

Observer No. 4. a. No.

- b. Yes, was more effective for open or targets that were plainly visible.

c. No.

- Observer No. 5. a. No. Exceptionally easy even for a novice.
 b. No.
 c. No.
- Observer No. 6. a. I believe the cross reticle is superior to
 a circular reticle.
 b.
 c.
- Observer No. 7. a. No.
 b. ?
 c. No.
- Observer No. 8. a. No.
 b. The present reticle pattern is more
 effective for square and rectangle type
 targets.
 c. No.
- Observer No. 9. a. No. Very easy.
 b. Yes. (The tree stump) where you can get
 both vertical and horizontal readings.
 c. No. I think this pattern is easy to read
 and very good.
- Observer No. 10. a. No.
 b. No.
 c. No.

Observer No. 11. a. I think it should be explained more in detail that the bottom of the reticle should be on target, as near the bottom as possible.

b. Yes. Targets near the ground are difficult to see, such as a man in the prone position, but can be seen.

c. No.

Observer No. 12. a. No.

b. No.

c. Yes. This allows adjusting from the side as with the pattern in use, but allows closer measurement around difficult targets.

Observer No. 13. a. No.

b. No.

c. Smaller reticle to use for point targets.

Observer No. 14. a. No.

b. No.

c. No.

Observer No. 15. a. No.

b. No.

c. I believe a circle or a square would be a better pattern.

Observer No. 16. a. It is difficult to use for me. Experience in its use would probably change this opinion.

- b. This type reticle is most effective on large, square or rectangular targets such as a bunker, building, tank or car body.
- c. I think that the present reticle is satisfactory (with practice), but area enclosed inside the "cross" should be less (with a correspondingly smaller light beam) so the user could maneuver the beam around or under wires, grass to avoid false ranges.

Observer No. 17. a. No.

- b. Linear type targets are easier to sight on.
- c. No.

Observer No. 18. a. The reticle pattern is very easy to use.

- b. The reticle pattern was more effective on small targets than the cross hairs since the cross hairs cover up small targets very easily.
- c. No. The pattern gives a very accurate picture of what you are shooting at, and allows you to compensate for such problems as tree limbs in the way since you can see them easily.

Observer No. 19. a. No.

Observer No. 20. a. No.

- b. More effective on larger targets (the bunker and tank). Small objects in the base of a "V" or a curve that receded from the operator would have a large measure of inaccuracy.

- c. Preferred pattern: Picture targets on a slope that are located at an elevation above the operator would have a measure of inaccuracy with the existing reticle. The small addition would assist as a guide for the operator.

Observer No. 21. a. No.

b. No.

- c. A bulls eye type pattern may seem more natural for most individuals.

Observer No. 22. a. Yes until you get used to it. An enclosed square would be better.

b. No.

- c. Enclosed square, because it would give a line to place the bottom of the target on.

Observer No. 23. a. No.

b. No.

c. No.

Observer No. 24. a. Yes. An enclosed-square reticle would be more accurate and easier to use.

- b. Yes. Trees because of their greater height were easier to range on with this reticle.

- c. Yes. An enclosed square with four radial lines. The radial lines could be graduated in mils.

Observer No. 25. a. No.

- b. A target of large area was easier to sight on a second time.

c. No answer.

Observer No. 26. a. No.

b. The reticle is most effective for distinct targets in open areas.

c. The present reticle makes it easy to center the target.

Observer No. 27. a. No; its use should be thoroughly explained.

b. On a large target, such as the stump, there was no problem. The reticle was easily placed on the whole target. What part of a small target to place the reticle on was a problem.

Question 5. Are there any battlefield conditions and environments under which you think either of the 5 positions would be ineffective or difficult to use? Explain where necessary.

Observer No. 1. No answer.

Observer No. 2. No answer.

Observer No. 3. I do not think the battlefield conditions would significantly affect the positions.

Observer No. 4. Shoulder-held kneeling and tripod-mounted high would be ineffective since these positions would expose the observer.

Observer No. 5. I feel an O. P. requires more concealment. The prone position affords concealment but cannot be used where there is high grass, etc. while the tripod (high) would be impractical in the open.

Observer No. 6. High tripod would be unwise. It makes a good target for small arms fire.

- Observer No. 7. Tripod-mounted might be difficult as far as concealment is concerned.
- Observer No. 8. Tripod-mounted high and bipod-mounted prone positions will be impractical and sometimes difficult to use during fast-moving situations.
- Observer No. 9. Low-tripod mounted for fast-moving situations, tripod-mounted for ideal conditions.
- Observer No. 10. No.
- Observer No. 11. Shoulder-held kneeling would be ineffective against moving targets.
- Observer No. 12. The high tripod would be easy to observe. It seems almost useless under battle conditions.
- Observer No. 13. No answer.
- Observer No. 14. Holding the gun-type design without a support would be ineffective in almost all cases. Using the bipod or sandbags would do well in all cases.
- Observer No. 15. Any position in which the instrument is not supported by a mechanical device would be ineffective, especially for small targets.
- Observer No. 16. I have no battlefield experience, but the high tripod position, and possibly the low tripod position would require exposing the user to enemy view.
- Observer No. 17. Conditions will vary.
- Observer No. 18. The two tripod mounted positions would be difficult to use in combat where there is an advance going on, with the F. O. constantly displacing forward. The time to set up and take down the equipment would be prohibitive.
- Observer No. 19. A high tripod, of course, exposes the operator.

Observer No. 20. No. I feel the operator would rapidly adjust himself to the best possible position as determined by the battlefield conditions and his environment at the time.

Observer No. 21. High tripod not suitable for most combat situations. Observer is wholly dug in and could use low tripod placed on edge of hole. An adjustable tripod would be handy for use inside of buildings when sighting through a window.

Observer No. 22. The tall tripod might be impractical in combat because you would not have enough cover.

Observer No. 23. To me the high tripod is ineffective in any battlefield condition.

Observer No. 24. Yes. Wind will affect steadiness in the shoulder-held standing position. Tripod-mounted high position will allow possible exposure to the enemy.

Observer No. 25. No answer.

Observer No. 26. I would be more comfortable with the bipod-mounted system. The system is steady and allows ease of concealment.

Observer No. 27. The high tripod position would be impractical because it would be difficult for an observer using this position to conceal himself from the enemy.

Question 6. Are there any special problems you can visualize that may come up in the battlefield concerning carrying or operating this equipment?

Observer No. 1. Any added piece of equipment would cause a burden to the forward observer. He carries at the present time all the equipment he can handle and do his job effectively.

- Observer No. 2. No answer.
- Observer No. 3. Not if the weight is kept under 25 pounds.
- Observer No. 4. 1. Weight could be a factor.
2. LASER would be ineffective in densely populated wooded areas.
- Observer No. 5. Bore-sighting.
- Observer No. 6. No answer.
- Observer No. 7. No answer.
- Observer No. 8. Weight and skill of operators are the only two problems that I think will affect the operation of the equipment.
- Observer No. 9. No.
- Observer No. 10. The shock of riding in a military vehicle. Keep weight down.
- Observer No. 11. The weight should be reduced to about half. First, the material should be of aluminum. Second, the weight of the power source could be reduced, using other means. Third, the bipod should be moved up and the hand grip moved back near the trigger.
- Observer No. 12. No answer.
- Observer No. 13. At present it is too bulky. Should be incorporated in B. C. Scope or other azimuth device.
- Observer No. 14. Based on limited knowledge, I can't visualize any significant problems.
- Observer No. 15. Maintenance.
- Observer No. 16. None in addition to the problems already encountered in using scopes, etc.

Observer No. 17. No.

Observer No. 18. There would be a problem in combat of the enemy's O. P. picking up the flash of the instrument in operation betraying the position of our F. O.

Observer No. 19. No answer.

Observer No. 20. The power supply. We are told a battery will be the ultimate source. This should be adequate for an optimum number of shots. Also, a means of counting the shots expended should be incorporated, something similar to the counting of the films used on a camera. This would alert operator to near expenditure of battery. Also, either instruction to the operator or a conversion factor for different extremes of temperature. Perhaps 50 shots at Zero, 75 shots at near freezing, and 100 at 70° and above.

Observer No. 21. Added weight and bulk for F. O. parties is always a problem. The total is pretty staggering when all equipment is considered radios, telephones, repair (?) batteries, weapons, ammo, rations, water, etc.

Observer No. 22. No. It would probably replace the B. C. Scope and would not be too heavy.

Observer No. 23. I think the generator will be the biggest problem. Speaking from experience with radar generators, I would like to see the generator built for this system mounted on a jeep since the F. O. section will be increased by one vehicle.

Observer No. 24. Maintenance, especially boresighting, would be a problem.

Observer No. 25. No answer.

Observer No. 26. No answer.

Observer No. 27. Maintenance should be simple enough to be handled by first echelon maintenance.

Question 7. What suggestion do you have concerning the future design of the system?

Observer No. 1. No answer.

Observer No. 2. Include azimuth and vertical angle of the target.

Observer No. 3. The azimuth should be capable of being read directly. Same with the vertical angle. The distance should be read directly in meters.

Observer No. 4. 1. Design should be simple.
2. Weight should be cut to a minimum.
3. Device such as sling should be added to carry LASER.
4. LASER should be a one piece unilateral design.
5. Should have better sighting device.

Observer No. 5. Attempt to incorporate a reflex sight on a coincident axis with the LASER beam. This, I feel, would eliminate the need for bore-sighting.

Observer No. 6. Make the legs of the bipod swing about the long axis of the "rifle."

Observer No. 7. Keep the weight down as much as possible. It was not difficult for me to handle however. A very small man might have trouble.

- Observer No. 8. Aluminum should be used for the construction of the equipment.
- Observer No. 9. Make sure that there is as little equipment for the F. O. as possible; that it is light yet long-lasting and inexpensive as possible.
- Observer No. 10. Do away with the stock. Only contact should be the eye with the telescope.
- Observer No. 11.
- Observer No. 12. Balance it.
- Observer No. 13. Reduction in size.
- Observer No. 14. A selector whereby the observer could, at his discretion, select large range brackets to be sensitive i. e. could select a return over 2000M the device would reject all targets closer than 2000M. The device should still be capable of sensitivity at all ranges in case the observer is in doubt and can't put the target in a range bracket.
- Observer No. 15. If feasible, considering the weight and delicacy of the instrument, the reticle pattern and the horizontal and vertical motions should be designed so that the instrument can be used by observation personnel to conduct HB & CI registrations and the location of targets.
- Observer No. 16. I suggest a low tripod mount with some device built in for measuring azimuth and vertical angle. A fast and slow motion with a lock on device should be provided. A powerful scope (at least 10x) for viewing with some type of sights for hasty location determination. A pistol grip with some type of press trigger at the rear of the gun. The beam should be narrowed to help avoid wires and other obstructions and still be exactly on the desired target.

- Observer No. 17. System should be constructed so that shoulder held position will allow the operator to support the instrument better. Front hand grip is too far forward in model.
- Observer No. 18. I suggest the future design of the range finder for an F. O. be the rifle-type configuration with bipod. I think a sling would greatly facilitate carrying the ranger. I suggest the possibility of a reflex action lens, similar to the reflex cameras on the market, be investigated to permit the sight picture to be taken along the actual axis the light beam travels on. I also suggest the possibility of using the instrument in the target area survey be investigated. If the accuracy of the instrument can be increased to the desired degree, a tripod mounted instrument could be used. Further, there should be a comparison of the capabilities of the planned instrument and a light ranging instrument already in use in the LaCrosse system. There is a possibility this instrument can replace the one used in the LaCrosse system.
- Observer No. 19. Have a rifle configuration with bipod. Be able to attach a tripod mount that has an azimuth ring.
- Observer No. 20. Try to balance the equipment which I feel should result in something similar to your present mock-up. Most men are familiar with the rifle and its shape and similarity to this weapon has many natural advantages. (Do not make the result a battlefield identity piece of equipment i. e. not something the enemy could identify if they see the bearer.)
- Observer No. 21. Include in the mount for tripod use an azimuth measuring scale. In a stable situation, an orienting line can be established by survey - then both accurate range and azimuth could be obtained.

- Observer No. 22. Make it as small and as light as possible. A low tripod mount would be the best. An azimuth and vertical scale should be included.
- Observer No. 23. No answer.
- Observer No. 24. I think the system would be a great benefit to a unit if it could be used as a range finder and also as a B. C. scope. The system could be used to fire a modified high burst or center of impact.
- Observer No. 25. I suggest a system that can be handled like a rifle in the prone, sitting, and standing positions.
- Observer No. 26. Suggestions are included in the answers to the questions above.
- Observer No. 27. It should be smaller and lighter. It could be combined with the B. C. scope to yield one observing instrument. If that were the case two eyepieces would be advisable to increase the observer's field of view.

Question 8. Comment on the manner in which the experiment was conducted? Cite factors.

- Observer No. 1. No answer.
- Observer No. 2. The only detrimental item was the fact that this was run concurrent with the regular assignment of the individuals and this tended to detract from both activities.
- Observer No. 3. Excellent.
- Observer No. 4. Experiment was conducted in an excellent manner. Weather conditions were excellent for experiment.

- Observer No. 5. Efficiency was the keystone, but I do feel that we could have had more freedom in selection of positions i.e. sitting, kneeling, prone, etc.
- Observer No. 6. Good planning, well executed.
- Observer No. 7. The experiment was conducted very well by all personnel concerned. I enjoyed it very much.
- Observer No. 8. No comments. Experiment was conducted in a superior manner.
- Observer No. 9. The instructions received were excellent, but I believe more definite instructions should have been given on sighting of the instrument itself.
- Observer No. 10. Experiment conducted in excellent manner. No factors which were detrimental.
- Observer No. 11. The ground should be more level with less rocks and bushes around positions.
- Observer No. 12. Well done.
- Observer No. 13. No comments.
- Observer No. 14. Conducted in an excellent manner.
- Observer No. 15. No answer.
- Observer No. 16. All phases of the experiment were conducted in an excellent manner. Well organized and well operated. I would like to have had more time to actually use the LASER - interesting, but probably not in the scope of the experiment.
- Observer No. 17. Excellent.

- Observer No. 18. The experiment was conducted in an adequate manner. I think there should have been provision made for an unexpected target to pop up and for a moving target. Both would have given the observers a chance to react to a combat type situation and would have increased the scope of the investigation.
- Observer No. 19. Very well.
- Observer No. 20. I feel that we could have attended a classroom briefing with a showing of a limited number of films to demonstrate errors on the part of operators would have resulted in better performance. We had to experience the errors and see the results to learn this.
- Observer No. 21. No detrimental effects on my performance. However, I don't believe the exercise in sighting has accomplished a great deal. The ability to obtain a correct sight picture is no more difficult than any weapon or item of similar design.
- Observer No. 22. None.
- Observer No. 23. No answer.
- Observer No. 24. The pictures were not as clear as they should have been for the particular day. If pictures had been clearer we could have easier determined what mistakes we were making in sighting.
- Observer No. 25. Manner of presentation and the conditions of the day were extremely helpful in obtaining good sight pictures.
- Observer No. 26. The targets should have been pointed more clearly initially.
- Observer No. 27. It was clearly explained and conducted in an excellent manner. It was enjoyable and a good experience working with the new device.

Question 9. Write any comments you wish concerning the equipment or the experiment.

Observer No. 1. No answer.

Observer No. 2. No answer.

Observer No. 3. The breadboard model proved to me that the concept of the LASER has tremendous application as a range finder.

Observer No. 4. No answer.

Observer No. 5. No answer.

Observer No. 6. No answer.

Observer No. 7. A step in the right direction. The F. O. for years has needed an improved method of target location.

Observer No. 8. Recommend that the modifications discussed during the briefing be made and the equipment be service tested as soon as possible. We need it. Recommend that a built-in compass be added to the equipment with a locking device similar to the M-2 compass connected to the trigger, so that when the trigger is pulled the locking device will lock the magnetic needle of the compass. By this method the F. O. will be able to read the azimuth to the target direct from the dial of the compass and of course the range to the target from the range scale of the instrument or the system designed to get the range.

Observer No. 9. No answer.

Observer No. 10. No answer.

Observer No. 11. None.

Observer No. 12. No answer.

- Observer No. 13. 1. Recommend tests be conducted using present conduct of fire techniques as opposed to using LASER techniques. This should be a live firing exercise on unfamiliar terrain. One observer would be equipped with M2 compass and map; the other with M2 compass, map and LASER. Experiment would determine comparison speed and accuracy between the two techniques.
2. Further recommend experimental model be designed for use on crew chief's cupola of M113 personnel carrier for use by S. P. Bns (recon & survey parties) in conjunction with an azimuth indicator.

Observer No. 14. I might be out of line, but I think this system is very important to the Artillery. Also the system is, in my opinion, without major flaws and I hope the time lag from approval to troop use will be a short one. You can always improve something forever never utilizing it, but I feel that this would be such a boon to the Artillery that troop use should come at the earliest possible date. I couldn't find even a minor flaw and thinking back on my observed fire training I contemplate very satisfactory results with this system.

Observer No. 15. If the field of view was large enough the instrument could be used by the observer in the adjustment of fire. I do not believe, however, that the use of the instrument for the adjustment of fire should receive a high priority as a design goal.

It should be noted that target survey, CI, & HB could be performed utilizing only one O. P. with this instrument. I think a study should be made to determine the feasibility

of integrating this instrument with "FADAC" so that the process of acquisition of target data to the production of the firing data would be completely automatic.

Observer No. 16. None other than those already made.

Observer No. 17. No answer.

Observer No. 18. The conference after the viewing of the pictures I shot the day before could have been improved by lists of questions, similar to this report, which would be reviewed prior to the conference to suggest ideas to be brought out. Overall, I think the instrument will definitely be an asset to the Forward Observer, and by tying it in with a FDC system, should decrease the time necessary for the observer to bring fire on a target to a little over the time of the first round. I was impressed highly with the operation of the breadboard model particularly with the cut-out circuit to permit shooting through telephone wires at a target.

Observer No. 19. No answer.

Observer No. 20. I feel a vehicular mount for the Forward Observer vehicle would be of advantage during fast moving situations. The use of the instrument as a hasty survey instrument has been discussed.

Observer No. 21. 1. Clearly establish the need for such an item. That is, what is its value and precisely what do you expect to gain.

2. In fast moving situations this item is of questionable value to a F. O.

3. Based on what you expect to gain (only range for F. O. ? integrated with survey and a computer system?) determine its most appropriate level of use - F. O., invaluable to battalion for use in stable situations, invaluable to survey sections, etc.

4. Run comparison tests to determine the value of a range only device for Forward Observers.

Observer No. 22. No answer.

Observer No. 23. I believe the system should be designed to utilize both the low mounted tripod and bipod.

Observer No. 24. The system does definitely have a place in the Artillery. With this system the unit would be able to fire for effect in 90% of the targets after a valid registration. This would save ammunition and give a greater degree of surprise fire. The explanation of the use and operation of the system was excellent.

Observer No. 25. No answer.

Observer No. 26. No answer.

Observer No. 27. Concerning the experiment, a longer briefing, including the uses and the proper way of using the system, would have been appropriate. To the average person, the operation of the system is not as important as what the system can do. I think many more targets should be ranged and it would be beneficial to everyone. It was good that the targets were of different shapes and sizes and at different ranges. The system was easy to use.

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